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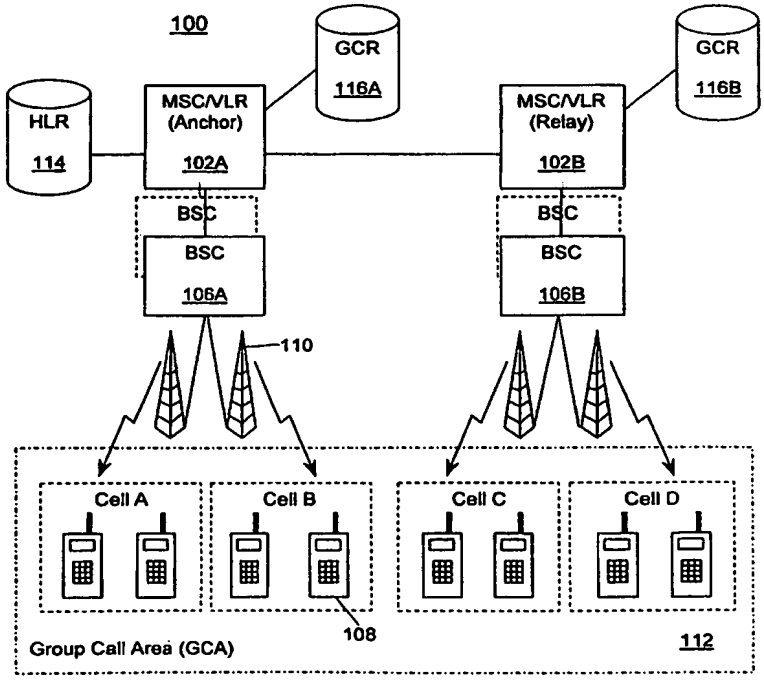
(54) Title: SYSTEMS AND METHODS TO ASSIST A CELL CHANGE OPERATION OF A MOBILE STATION, INCLUDING METHODS OF PERFORMING AN INTER-BSC CELL CHANGE DURING GROUP CALLS

(57) **Abstract**

Systems and methods to assist a handover, or cell change, of a Mobile Station (MS) participating in a group call. A Group Call Register (GCR) includes a database accessible by a Mobile Switching Center (MSC). The MSC is coupled to and has an MSC service area difined by at least one Base Station Controller (BSC); the BSC has a first BSC service area at least partially defined by a first cell associated with a Base Tranceiver Station (BTS) coupled to the BSC. The database includes conventional information defining at least on Group Call Area (GCA) comprising at least the first cell, and may further include information identifying a second cell within the GCA and within a second BSC service area adjacent to the first BSC service area. The information identifying the cell(s) in the GCA is useable by the MSC and/or BSC to provide parameters associated with the second cell to an MS participating in the group call, whereby the MS can perform a cell change operation when moving from the first cell to the second cell. The parameters associated with the second cell, and can be broadcast to the MS on a control channel associated with the group call channel in the first cell.



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SYSTEMS AND METHODS TO ASSIST A CELL CHANGE OPERATION OF A MOBILE STATION, INCLUDING METHODS OF PERFORMING AN INTER-BSC CELL CHANGE DURING GROUP CALLS

TECHNICAL FIELD OF THE INVENTION

The present invention is directed, in general, to wireless communications systems and, more specifically, to systems and methods to assist a cell change operation of a Mobile Station (MS), including methods of performing an inter-Base Station Controller (BSC) cell change during group calls.

BACKGROUND OF THE INVENTION

In recent years, the proliferation of wireless telecommunications systems has been fueled by continual advancements in the quality and functionality of such systems. In particular, the innovative services generally defined by the specifications for Global System for Mobile Communications (GSM) networks has made GSM networks the world standard against which all other wireless systems are measured. One recent advancement in GSM services is the development of Advanced Speech Call Items (ASCI), which refers to a set of work-group services added to the GSM specifications.

One of the ASCI work-group services is Voice Group Call Service (VGCS), which provides a facility for a calling subscriber to establish a call to a predefined group of service subscribers, or "group members," located in a predefined geographical area composed of a cluster of cells and referred to as a Group Call Area (GCA). The service is characterized by a half-duplex transmission mode in which only one member of the group is allowed to talk

at any one time; listening group members are said to be in "Group Receive Mode" and the talking group member is said to be in "Group Transmit Mode."

Another ASCI work-group service is Voice Broadcast Service (VBS), which also provides the facility for a calling subscriber to establish a call to a predefined group of service subscribers, or "group members," in a predefined GCA. Unlike the VGCS service, however, the VBS service is characterized by a uni-directional transmission mode in which the calling subscriber broadcasts speech to the predefined group of service subscribers; the VBS service is basically a subset of the VGCS service wherein only the calling subscriber is allowed to speak and group call members are only allowed to listen.

Applications for VGCS and VBS services will typically involve multiple group members in a small GCA, and should provide spectrum efficient solutions. For conventional VGCS and VBS calls, all of the listening subscribers in a network cell share the same downlink channel and the wireless network has no knowledge of the listening subscribers. As a result, the listening subscribers, who are said to be in Group Receive Mode, have no capability to perform a conventional handover sequence when moving to a new cell. Instead, it may be necessary for a listening subscriber's Mobile Station (MS) to leave the VGCS/VBS call and then rejoin the VGCS/VBS call after moving to a new cell. Conventional handover procedures, however, can be used for a subscriber in Group Transmit Mode.

In order to minimize the time it takes for a listening subscriber to change cells and rejoin the VGCS/VBS call, information including the identity of neighboring cells within a Base Station Controller (BSC) service area that

belong to the GCA, and cell reselection parameters corresponding to those neighboring cells, is transmitted as part of system information on a Slow Associated Control Channel (SACCH) channel associated with the VGCS/VBS call. When a request is made to establish a VGCS/VBS call, a Mobile-services Switching Center (MSC) obtains a list of the cells to participate in the group call from a Group Call Register (GCR). A GCR is a database function that holds the group call attributes for many predefined group calls. Included in the group call attributes for each group call is a list of cells within one or more MSC service areas that are to participate in the specific group call. Each MSC sends an assignment message to each of its associated Base Station Controllers (BSCs) for each cell in a BSC service area that is within the GCA; each such message requests the BSC to establish a VGCS/VBS channel in the identified cell within the GCA. Information about which cell(s) in a BSC service area belong to a GCA can be extracted from the assignment messages. A BSC, however, receives no information from a MSC to identify cells outside of the service area of the BSC that also belong to the GCA; *i.e.*, the GCR does not contain any information that can be used to identify cells within the GCA that are located in BSC service areas adjacent to a particular BSC service area. Therefore, according to the existing GSM specifications, it is not possible to perform an inter-BSC handover for a subscriber in Group Transmit Mode, or support an inter-BSC cell change for a subscriber in Group Receive Mode. The inability to perform such handovers, or cell changes, requires a MS to leave the group call and search for a Notification channel (NCH), after moving into a cell located in an adjacent BSC service area, in order to determine the

identity of the group call channel in the new cell. Accordingly, there exists a need in the art for apparatus, systems and methods to assist a handover, or cell change, operation when a MS moves from a first BSC service area to a second BSC service area while participating in a group call.

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SUMMARY OF THE INVENTION

To address the deficiencies of the prior art, the present invention provides apparatus, systems and methods related to the use of information stored in a Group Call Register (GCR) to assist a handover, or cell change, operation of a wireless Mobile Station (MS) in a Public Land Mobile Network (PLMN). In one embodiment, the GCR includes a database accessible by a Mobile-services Switching Center (MSC). The MSC is coupled to, and has a MSC service area defined by, at least one Base Station Controller (BSC); the BSC has a first BSC service area at least partially defined by a first cell associated with a Base Transceiver Station (BTS) coupled to the BSC. The GCR includes conventional information defining at least one Group Call Area (GCA) including at least the first cell, and can further include information identifying a second cell within the GCA and within a second BSC service area adjacent to the first BSC service area; the second BSC service area can be within a MSC service area the same as, or different to, the MSC service area associated with the first BSC service area. If more than one cell adjacent to the first cell is within the GCA and within a second BSC service area, the GCR can include information identifying all such adjacent cells. The information identifying the adjacent cell(s) is useable by the MSC and/or BSC to assist a Mobile Station (MS) perform a handover, or cell change, operation when the MS moves from a first BSC service area to a second BSC service area while participating in a group call.

The present invention provides systems and methods that can overcome the problems in the prior art that prevented an inter-BSC handover of a MS in Group Transmit Mode, and the failure of such prior art to support

an inter-BSC cell change when a MS is in Group Receive Mode. The present invention therefore overcomes the deficiencies of the prior art that potentially could cause a MS to drop out of a group call when the MS moves from a cell in one BSC service area to a cell in a second BSC service area. In the prior art, if a MS is in Group Receive Mode during a cell change, the MS must search for a notification channel (NCH) upon entering the new cell in order to identify and tune to the proper group call channel; if the MS is in Group Transmit Mode, it is also necessary to reestablish an uplink to resume transmission. According to the principles disclosed herein, information identifying adjacent cells outside a BSC service area, including cells outside the MSC service area, and the cell reselection parameters corresponding to those adjacent cells, is provided to a MS participating in a group call to assist the MS perform a handover, or cell change, when moving into such adjacent cell(s). The information can be communicated to the MS on a control channel associated with the group call channel, whereby the time required to rejoin a group call upon a cell change can be minimized or eliminated.

A PLMN typically includes a plurality of MSCs, BSCs and BTSs. Thus, in certain embodiments, the MSC capable of accessing the GCR is coupled to a second BSC; the second BSC has a second BSC service area associated therewith, and the second cell is within the second BSC service area. In such embodiments, the provisioning of a GCR with information identifying cells in adjacent BSC service areas and within the GCA provides support for inter-BSC cell changes when a MS is in Group Receive Mode. In related embodiments, the second BSC can be coupled to the (first) MSC by a second MSC; in such embodiments, the first MSC can be an "anchor"

MSC, and the second MSC can be a "relay" MSC, as described hereinafter. In such related embodiments, the provisioning of a GCR with information identifying cells in adjacent BSC service areas and within the GCA further provides support for inter-BSC handovers of a MS in Group Transmit Mode.

The principles of the present invention are particularly advantageous when used to support group calls in Global System for Mobile Communications (GSM) wireless networks, as generally defined by the Voice Group Call Service (VGCS) Technical Specification (GSM 03.68, Version 6.1.0, Release 1997) and the Voice Broadcast Service (VBS) Technical Specification (GSM 03.69, Version 6.1.0, Release 1997), both of which are incorporated herein by reference; the principles disclosed herein, however, may be used to enhance other existing or novel types of group calls, and may also be employed in wireless networks defined by alternative standards, such as Advanced Mobile Phone Service (AMPS), digital AMPS (D-AMPS) or Code Division Multiple Access (CDMA) based wireless networks.

In certain embodiments of a PLMN employing the principles disclosed herein, the MSC transmits information identifying the cell(s) in adjacent BSC service areas to a BSC during a setup process associated with a group call. The BSC can then provide this information to a MS participating in the group call and within the BSC service area, whereby it is not necessary for a MS to perform any transactions with the PLMN during a cell change; *e.g.*, it is not necessary that a MS search for a notification channel in a new cell in order to identify and tune to the proper group call channel.

Many systems and methods may be employed to take advantage of the principles disclosed herein. In general embodiments, a method for assisting a handover, or cell change, of a MS participating in a group call includes the step of receiving a group call request at a MSC, where the MSC has a MSC service area defined by at least one Base Station Controller (BSC); the BSC has a BSC service area at least partially defined by a first cell associated with a Base Transceiver Station (BTS) coupled to the BSC. An MSC, which may be an anchor MSC or a relay MSC, then accesses a Group Call Register (GCR) that includes information defining at least one Group Call Area (GCA) comprising at least the first cell; the GCR further includes information identifying cell(s) in a second BSC service area adjacent to the first BSC service area and within the GCA. The information identifying the cell(s) in the second BSC service area is then used to assist a handover, or cell change, of a MS participating in a group call when the MS moves from the first cell to the second cell.

In a specific embodiment, a method for managing a handover, or cell change, of a MS participating in a group call includes the step of transmitting the information identifying the cell(s) in the second BSC service area to a BSC during a setup process associated with the group call. In related embodiments, the method includes the steps of setting up a group call channel in a first cell of the first BSC service area, and broadcasting on a control channel associated with the group call channel in the first cell the information identifying the second cell(s) in the BSC service area adjacent to the first BSC service area and within the GCA.

The foregoing has outlined, rather broadly, the principles of the present invention so that those skilled in the art may better understand the detailed description of the exemplary embodiments that follow. Those skilled in the art should appreciate that they can readily use the disclosed conception and exemplary embodiments as a basis for designing or modifying other structures and methods for carrying out the same purposes of the present invention. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the invention in its broadest form.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, reference is now made to the following detailed description taken in conjunction with the accompanying drawings, in which:

FIGURE 1 illustrates a diagrammatic representation of certain functional elements of a Global Systems for Mobile Communications (GSM) network;

FIGURE 2A illustrates an exemplary process performed by an anchor MSC and a relay MSC in connection with setting up a group call;

FIGURE 2B illustrates certain attributes stored in a group call data record in a Group Call Register (GCR) in accordance with the principles of the present invention;

FIGURE 3 illustrates an exemplary flow chart of a group call set-up process;

FIGURE 4 illustrates an exemplary flow chart of a group call set-up process;

FIGURE 5 illustrates an alternative embodiment of the process illustrated in FIGURE 2A, as expanded upon in the process illustrated in FIGURE 3; and

FIGUREs 6 through 8 illustrate relevant portions of a group call set-up process performed at Base Station Controllers (BSCs), including alternative embodiments or implementations of this process.

DETAILED DESCRIPTION

The architectural and functional details of a Public Land Mobile Network (PLMN), such as a Global System for Mobile Communications (GSM) network, are generally well known to those skilled in the art. In order to better understand the particular features and advantages of the present invention, however, reference is first made to FIGURE 1, which illustrates a diagrammatic representation of certain functional elements of a GSM network 100. GSM network 100 includes one or more Mobile-services Switching Centers (MSCs). For purposes of describing certain services offered by the GSM network 100, two otherwise functionally-equivalent MSCs are illustrated; MSC 102A serves as an "anchor" MSC and MSC 102B serves as a "relay" MSC.

Each MSC has a service area geographically defined by at least one, but typically many, Base Station Subsystems (BSSs). Functionally, each BSS includes a Base Station Controller (BSC) and a plurality of Base Transceiver Stations (BTSs). In FIGURE 1, two BSCs are illustrated; BSC 106A, which is served by MSC 102A, and BSC 106B, which is served by MSC 102B. Each of the BSCs 106A, 106B has a service area defined by one or more BTSs that have an antenna system, generally designated 110, associated therewith; in FIGURE 1, BSC 106A has a service area defined by Cell A and Cell B, and BSC 106B has a service area defined by Cell C and Cell D. The BTSs provide, among other things, radio links between Mobile Stations (MSs), generally designated 108, and an associated BSC. In a typical network, numerous cells cover the geographic area to which the

network provides service; each cell will, to some degree, overlap adjacent cells to ensure good reception.

Each subscriber to a network has a service profile that specifies the attributes of the services the network is to provide that particular subscriber. The GSM network 100 stores these profiles, together with the current location of the subscriber's MS, in a Home Location Register (HLR) 114. Each MSC also has associated with it a Visitor Location Register (VLR), which is typically implemented as part of the MSC, as illustrated in FIGURE 1. A VLR, however, can be implemented separate from its associated MSC. A VLR obtains from the HLR 114 certain attributes necessary for call control and provision of subscribed services for a MS roaming in a MSC's service area.

Within each network cell, multiple "channels" are used for voice and data traffic and control signals. The channels can be of two general types: a traffic channel (TCH) carries speech and data traffic, and a control channel is used for transmitting control signals and synchronization information. There are four types of control channels: a broadcast control channel (BCCH); a common control channel (CCCH), a stand-alone dedicated control channel (SDCCH), and an associated control channel (ACCH). A BCCH is used to provide synchronization, frequency correction and general information. A CCCH is used for paging a MS and for requesting and granting access to a dedicated channel. A SDCCH is a bi-directional channel dedicated to a particular MS for use in registering with the network and setting up a call. An ACCH channel is associated with a TCH; a MS can receive information on an ACCH at the same time as a voice call on the associated TCH channel.

Networks conforming to the GSM standard are able to offer an advanced set of work-group services referred to as Advanced Speech Call Items (ASCI), which have been specified in a several technical standards publications of the European Telecommunications Standards Institute (ETSI). One of these ASCI work-group services is the Voice Group Call Service (VGCS), as generally defined by the VGCS Technical Specification (GSM 03.68, Version 6.1.0, Release 1997), which provides basic details for a facility within a PLMN for a calling subscriber to establish a call to a predefined group of service subscribers in a predefined geographical area called a Group Call Area (GCA). A GCA is composed of a defined cluster of cells. The group of service subscribers are referred to as "group members." The service utilizes a half-duplex transmission mode; *i.e.*, only one member of the group is allowed to speak at any one time. Thus, a MS will be in either a "Group Receive Mode" or a "Group Transmit Mode" once the subscriber joins a VGCS call.

Another ASCI work-group service is the Voice Broadcast Service (VBS), as generally defined by the VBS Technical Specification (GSM 03.69, Version 6.1.0, Release 1997). VBS is basically a subset of the VGCS, where only the calling subscriber is allowed to speak and group call members are only allowed to listen. The service uses a uni-directional transmission mode; *i.e.*, a calling subscriber broadcasts voice to the predefined group of service subscribers. For simplicity, both VBS and VGCS will be generically referenced herein as a "group call service," or collectively as "group call services," and a call using such services is referred to as a "group services call," or simply "group call."

Referring again to FIGURE 1 for a brief description of VGCS and VBS facilities within a GSM network 100, a Group Call Register (GCR) is a database function that stores attributes at each MSC for each group call that can be set up within the network. In FIGURE 1, anchor MSC 102A is associated with GCR 116A. Whereas an anchor MSC is responsible for managing a particular group call, its GCR maintains all attributes necessary for it to manage the group call. Each relay MSC also maintains a GCR; in FIGURE 1, relay MSC 102B is associated with GCR 116B. Whereas a relay MSC is not in control of setting up a group services call, its associated GCR can maintain a smaller subset of the attributes for each group call.

A group services call is initiated by a calling subscriber dialing a group ID number. The MSC associated with the cell in which the call is initiated obtains the attributes for the group call from its associated GCR. If the MSC determines from the attributes that it is a relay MSC, the call is forwarded to the anchor MSC 102A; it is the responsibility of the anchor MSC to take the necessary additional steps to establish the group call. A voice broadcast channel, consisting of a common downlink, is established in each cell in the GCA, subject to channel availability. The calling subscriber, however, will have a standard dedicated channel, consisting of both an uplink and downlink, during call establishment and for at least as long as the calling subscriber initially remains in Group Transmit Mode.

A subscriber that is a member of the group and roaming within any cell of the GCA is notified of a group call through a page on a notification channel (NCH). The MS joins the group call by tuning to the group call channel specified in the NCH, at which point the MS enters Group Receive

Mode. Unlike a conventional point-to-point call, however, the MS does not send any message to the BSC or MSC in order to join the call in Group Receive Mode. For group calls, all listening subscribers will share the same TCH within a given cell of a network; neighboring cells in the GCA will have a different channel assigned to the group call. Thus, when a MS roams to a new cell, it is necessary to switch to a new group call channel.

During a conventional call (*i.e.*, non-group services call), when a MS is in a dedicated mode, a MS roaming between cells requires a "handoff," or "handover," procedure. A handover involves setting up a new channel in the new cell and then switching the call to the BTS for the new cell when the MS switches to the new channel. In order to determine when a handover is necessary, a MS scans the BCCHs of neighboring cells during idle time periods, and obtains information identifying the neighboring cells on a slow ACCH (SACCH), which is a control channel associated with the TCH for a call. The MS measures the power levels of the BCCH signals, and information about these measurements is passed to the BSC.

Cell selection and handover decisions are based on the measurement results and various other parameters, such as the received power level and the reception quality. A BSC can typically maintain a table of up to 32 neighboring cells for each BTS and store the levels as they are received. A BSC performs intra-BSC handovers autonomously. If the handover will be to a cell controlled by another BSC, an "inter-BSC" handover is performed; in an inter-BSC handover, the BSC sends a list of preferred cells to its associated MSC, and the MSC controls the hand-over according to the list. If, however, a MS in a Group Receive Mode travels to a new cell, it has no

way of communicating with the BSC or MSC to coordinate a cell change. The MS must therefore leave the group call, listen to the NCH in the new cell to listen for a page for the group call, and then tune to the channel in the new cell allocated to the particular group call.

Referring now to FIGURE 2A, with continuing reference to FIGURE 1, an exemplary process 200 is performed by anchor MSC 102A and relay MSC 102B in connection with setting up a group call. Although the group call set-up processes at the anchor MSC and relay MSC differ in some respects, they can be treated basically the same for purposes of describing the invention disclosed herein; thus, the exemplary processes illustrated in FIGUREs 2 through 5 will be described primarily in connection with anchor MSC 102A. In a first step 202, the MSC receives a request for a group service call. As described in the GSM specifications, this request may come through BSC 106A from a subscriber in the MSC 102A service area, through another network such as the Public Switched Telephone Network (PSTN), or through MSC 102B from a subscriber in the MSC 102B service area. In response to receiving a request for a group service call, the MSC 102A queries GCR 116A (step 204) and receives information from the GCR (step 206) that specifies certain attributes necessary for setting up the group call.

Referring to FIGURE 2B, the attributes stored in a GCR for each group call, under the conventional GSM standards, are indicated in representative GCR group call data record 250 as "attributes defined by the standard." These attributes include only those necessary for the particular MSC with which the GCR is associated. Except for one attribute, a description of the attributes contained in data record 250 is not necessary for

an understanding of the invention disclosed herein. The GCRs 116A and 116 B each provide a database function including a list of cells within the service area of their respective MSC that are in the GCA for the purpose of requesting the assignment of group call channels in each of those cells. Therefore, the GCR 116A stores, for the illustrated GCA 112, a list including Cell A and Cell B; the GCR 116B stores a list containing only Cell C and Cell D. It should be noted that, as used herein, the terms "record" and "list" do not imply any particular type of database structure or data structure; "record" is used only to indicate a collection of attributes associated with a particular group call, and "list" is used to indicate a collection of multiple values for a particular functional or logical attribute, *e.g.* MSC cells within the GCA.

Unlike a GCR according to the conventional GSM standard, group call data record 250 can include additional information identifying additional cells that are within the GCA, and which neighbor, or are adjacent to, each BSC service area having cells within the GCA. Thus, in the exemplary network 100 of FIGURE 1, a group call record in GCR 116A can store an additional list that contains Cell C and/or Cell D. Similarly, GRC 116B can store an additional list that contains Cell A and/or Cell B.

Referring again to FIGURE 2A, with continuing reference to FIGURE 1, MSC 102A can receive from GCR 116A (step 206) a list of cells in neighboring BSC service area(s) having cells within the GCA, in addition to the list of cells within the MSC service area that are part of the GCA; the neighboring BSC service area(s) may be within the service area of MSC 102A or a different MSC, such as MSC 102B. In a step 208, MSC 102A sends to BSC 106A information sufficient for enabling that BSC to know

which cells in neighboring BSC service areas are in the GCA and, preferably, which of those cells have established group call channels. Similarly, MSC 102B can send to BSC 106B information sufficient for enabling that BSC to know which cells in neighboring BSC service areas are in the GCA. Several alternative processes are conceivable for enabling a BSC to know which cells in a neighboring BSC service area are part of the GCA; at least some of these alternative processes are described below in connection with FIGUREs 3 through 5.

Referring now to FIGURE 3, illustrated is an exemplary flow chart of a group call set-up process 300. Process 300 expands upon step 208 of process 200 illustrated in FIGURE 2A, and includes alternative methods for a BSC to determine which cells in a neighboring BSC service area are within a GCA. After MSC 102A receives a request for group call service at step 302, the MSC requests (step 304) and receives (step 306) from GCR 116A certain group call attributes as previously described with reference to FIGURE 2B. In a step 308, the MSC 102A sends a group call setup message to each BSC that has a cell within the GCA and within the service area of the MSC, such as BSC 106A. The setup message could be sent prior to the MSC receiving all of the requested information at step 306; *e.g.*, before the MSC receives the list of cells in neighboring BSC call areas within the GCA. Upon receiving this setup message, a BSC will, among other things, allocate space for storing information required to setup and control the group call channels in cells within its service area.

At step 310, the MSC 102A sends BSC 106A a request for assignment of group call channel, or "assignment message," for each of its

cells in the GCA. Thus, for exemplary GCA 112, BSC 106A will receive a request to assign a group call channel in Cell A and a request to assign a group call channel in Cell B. If MSC 102A has any additional BSCs with cells in the GCA, the MSC would also send a request for assignment of a group call channel to each of those BSCs. As will be subsequently described in connection with FIGUREs 6 through 8, a BSC can determine from an assignment message which of the cells within its service area are within the GCA. Alternatively, the MSC could send a list of all cells in the MSC service area participating in the group call, or a subset of this list applicable only to each specific BSC; sending a subset of this list, however, might require additional hardware or software resources at a MSC and/or GCR.

At step 312, MSC 102A sends a list of cells in neighboring BSC service areas that are within the GCA; this step is performed by the MSC for each BSC in its service area. As an alternative to sending the entire list received from the GCR, the MSC 102A could send a subset of the group call neighboring cell list that only includes cells that neighbor each particular BSC, which would lessen the processing burden on a BSC. It would, however, increase either the overhead imposed on the MSC, if the MSC determines the proper subset, or on the GCR, if the GCR stores such a subset of the list or additional attributes that enable the GCR to generate the subset. For example, if an MSC determines the subset for each of its associated BSCs, the MSC must maintain a list of cells in BSC service areas neighboring each such BSC. Thus, MSC resources will be required to store and maintain information used to determine the neighboring cell list for each

group call. Similarly, network resources would be required to maintain information in the GCR identifying neighboring cell lists for each BSC.

Referring now to FIGURE 4, illustrated is an exemplary flow chart of a group call set-up process 400. Process 400 is substantially similar to process 300, except that the last two steps are reversed; *i.e.*, steps 402, 404, 406 and 408 correspond to steps 302, 304, 306 and 308, respectively, of process 300. At step 410, the MSC sends information that enables a BSC to know which cell(s) in a neighboring BSC service area are within the GCA, and then, at step 412, the MSC sends a message requesting assignment of a group call channel for each such cell.

Referring now to FIGURE 5, illustrated is an alternate embodiment of process 200, shown and described with reference to FIGURE 2A, as expanded upon in process 300, shown and described with reference to FIGURE 3; steps 502, 504 and 506 of process 500 are substantially the same as steps 302, 304 and 306, respectively, of process 300. At step 508, MSC 102A sends a group call set-up message to BSC 106A, and any other BSCs in the MSC service area, as well as information identifying cell(s) within any neighboring BSC service areas and within the GCA. As previously indicated, this information may be a group call neighboring cell list for the MSC stored in the GCR, or a subset of it applicable to BSC 106A. At step 510, the MSC 102A sends to BSC 106A a message requesting assignment of a group call channel for each cell in the BSC service area that is within the GCA. As previously noted in connection with FIGUREs 3 and 4, the actions identified in steps 508 and 510 can be performed in any order, except that the call set-up message must be sent to the BSC prior to sending channel

assignment messages; *i.e.*, the information identifying cells within any neighboring BSC service areas and within the GCA can be transmitted after the message requesting assignment of group call channel(s).

At step 512, MSC 102A receives information from each BSC relating to any failure to set up a group call channel in cells within the BSC service area that are within the GCA; a BSC may be unable to set up a group call channel within a cell, for example, due to call traffic. For the GCA cells within the service area of MSC 102A, BSC 106A and any other BSCs within the MSC 102A service area will provide this failure information. Additionally, MSC 102A may exchange information with neighboring MSCs, such as MSC 102B, thereby allowing MSC 102A to determine which cells in neighboring MSC service areas and within the GCA do not have a group call channel assigned. At step 514, this information can then be communicated to BSC 106A, as well as to all other BSCs in the MSC service area that have cells within the GCA; using this information, a BSC is able to update its list of cells in neighboring BSC service areas so as not to include cells that have not allocated a channel for the group call.

Turning now to FIGUREs 6 through 8, illustrated are relevant portions of the group call set-up process at BSCs 106A and 106B, including alternative embodiments or implementations of this process; the processes will be described only with reference to BSC 106A. As illustrated in FIGURE 6, process 600 begins at step 602 with BSC 106A receiving from MSC 102A a request for assignment of a group call channel; multiple requests would be received if the BSC has more than one cell in the GCA. For example, a request to assign a group call channel in Cell A can be sent to BSC 106A,

which will then assign a TCH for use by group subscribers having MSs located in Cell A. Step 602 can be repeated for Cell B, if it is within the GCA, as well as any other cells within the BSC 106A service area that are within the GCA. At step 604, for each cell that is assigned a group call channel, BSC 106A determines which cell(s) in a neighboring BSC service are also within the GCA; this determination is based, at least in part, on information received from the MSC 102A. All, or part, of this information may be derived from the request(s) for channel assignment received by BSC 106A; the remainder, or possibly all, of this information can come from the MSC 102A, as will be more fully described with reference to FIGUREs 7 and 8.

For each cell in the GCA that has a group call channel assigned, the BSC 106A, at step 606, instructs the BTS associated with each cell to activate a group call channel. In step 608, the BSC 106A instructs each BTS to broadcast on a control channel information related to the cells that neighbor the cell and that are also within the GCA. To construct this special neighboring cell information for broadcast on the control channel, the list of cells in the GCA that neighbor the BSC service area and the list of GCA cells within the BSC service area can be compared to a standard list of neighboring cells maintained for each cell. According to conventional GSM standards, the control channel used to broadcast the neighboring cell information can be a slow Associated Control Channel (SACCH). Using the list of neighboring cells in the GCA, a MS can monitor the BCCH of such neighboring cells, and preferably only those cells, when determining the selection of a new cell for continuing with the group call as the MS moves within the network 100 service area. Furthermore, the provisioning of

additional information in a GCR, as disclosed herein, can enable a BSC to ensure handover of a MS in Group Transmit Mode to a cell within the GCA and located in an adjacent BSC service in a different MSC service area.

The information identifying the neighboring cell(s) in the GCA can also be used by the MSC and/or BSC to provide parameters associated with a group call channel in the second cell (in the second BSC service area) to a MS participating in a group call. For a MS in Group Transmit Mode, a conventional handover procedure can be used when moving to another cell; *e.g.*, a HANDOVER COMMAND message can be sent to the MS on a FACCH. For a MS in Group Receive Mode, cell reselection parameters can be sent in a new SYSTEM INFORMATION message on a SACCH; the cell reselection parameters would be for the neighboring cells within the GCA.

When a MS is not participating in a group call, the cell reselection process to determine the optimum neighboring cell can be performed when a MS is in idle mode. The cell reselection process is performed for each frequency listed in the standard neighboring cell list, and consists of measuring the signal strength of the RF carrier of the BCCH, synchronizing to the BCCH, and receiving cell parameters from a system information message transmitted on the BCCH. When a MS is participating in a group call, however, the cell reselection parameters can be communicated to a MS on a control channel, such as the SACCH, associated with the group call channel in the first cell, thereby eliminating the need to synchronize to a BCCH to receive the parameters and, thus, reducing the amount of speech interruption that would occur for MSs in Group Receive Mode.

Referring now to FIGURE 7, illustrated is a process 700 defining a more detailed exemplary implementation of the process 600 described with reference to FIGURE 6. BSC 106A receives from MSC 102A, at step 702, a group call set-up message and, at step 704, information identifying cells in neighboring BSC service areas that are within the GCA. As previously described in connection with step 602 of process 600, this information can take several different forms, depending on the preferred allocation of processing overhead between the MSC and BSC. At step 706, for each cell within the BSC service area and within the GCA, the BSC 106A receives from the MSC 102A a message requesting assignment of a group call channel; at step 708, the BSC 106A sets up the group call channel(s) as specified in the assignment message(s). BSC 106A then receives, at step 710, information, if any, indicating whether any cells in the GCA that neighbor the BSC service area have not established group call channels and are, therefore, not available to participate in the group call. The BSC 106A then updates its neighboring cell list for the group call so as not to include cells that have not allocated a channel for the group call. Step 714 is substantially similar to step 608 of process 600.

Referring now to FIGURE 8, illustrated is a process 800 defining a more detailed exemplary implementation of process 600 described with reference to FIGURE 6. At step 802, BSC 106A receives from MSC 102A a group call setup message. At step 804, the BSC 106A receives from MSC 102A a list of cells in the GCA, including those that neighbor the MSC service area. The BSC then compares, at step 806, this list to a standard neighboring cell list to determine which of its standard neighboring cells are

within the GCA. Beginning at step 808, the BSC 106A receives from the MSC a message, or messages, requesting assignment of a group call channel for each cell in the BSC service area that is within the GCA; alternatively, the channel assignment messages may be received after step 802 and before step 804, depending on the preferred implementation. At step 810, the BSC 106A sets up the requested group call channel(s). Steps 812, 814 and 816 are substantially similar to steps 710, 712 and 714, respectively, of process 700 described with reference to FIGURE 7.

Based on the principles of the present invention as described with reference to the embodiments disclosed herein, those skilled in the art will recognize that a GCR, which may include additional information beyond that specified by the GSM standards, can be employed in various apparatus, systems and methods to identify cells in neighboring BSC service areas and within a GCA; the information identifying the neighboring cells is useable by a MS to assist a handover, or cell change, of a group call when a MS moves from a first BSC service area to a second BSC service area. Using this neighboring cell information, a MS can perform an inter-BSC handover from one cell in the GCA to another cell in the GCA for a subscriber in Group Receive Mode. Use of the neighboring cell information can also support an inter-BSC cell change for a subscriber in Group Receive Mode. A BSC, through a BTS, causes to be transmitted on a control channel associated with a group call channel information identifying all the neighboring cells that belong to the GCA and the cell reselection parameters corresponding to those cells. A MS in either of the group call modes is thereby able to obtain this information and use it to reselect only a neighboring cell within the GCA. By assisting

the handover, or cell change, of a MS as it moves within a wireless network, unnecessary delays in rejoining a group call caused by uncertainty as to which cell to select, or in obtaining the cell reselection parameters corresponding to those cells, can be reduced or avoided.

The forgoing detailed description is of various embodiments employing the principles of the invention. Those skilled in the art, however, will recognize that substitutions, rearrangements, omissions or other modifications to those embodiments can be made without departing from the principles disclosed herein; all such alternative embodiments are intended to be within the scope of the claims recited hereinafter.

CLAIMS

WHAT IS CLAIMED IS:

1. A Group Call Register (GCR) for use in a Public Land Mobile Network (PLMN), said GCR comprising:

a database accessible by a Mobile Switching Center (MSC), said MSC coupled to and having a MSC service area defined by at least one Base Station Controller (BSC) having a first BSC service area at least partially defined by a first cell, said database including information defining at least one Group Call Area (GCA) comprising at least said first cell, said database further including information identifying a second cell within said GCA and within a second BSC service area adjacent to said first BSC service area, said information identifying said second cell useable by said MSC to provide parameters associated with said second cell to a Mobile Station (MS) participating in a group call, whereby said MS can perform a cell change operation when moving from said first cell to said second cell.

2. The GCR recited in Claim 1, wherein said MSC causes said parameters associated with said second cell to be communicated to said MS on a control channel associated with a group call channel in the first cell.

3. The GCR recited in Claim 2, wherein said control channel is a slow associated control channel (SACCH).

4. The GCR recited in Claim 1, wherein said MSC communicates said information identifying said second cell to said at least one BSC during a setup process associated with said group call.

5. The GCR recited in Claim 4, wherein said BSC is coupled to said MSC by a second MSC.

6. The GCR recited in Claim 1, wherein said group call comprises a Voice Group Call Service (VGCS).

7. The GCR recited in Claim 1, wherein said group call comprises a Voice Broadcast Service (VBS).

8. The GCR recited in Claim 1, wherein said MS does not perform any transactions with the PLMN during said cell change.

9. A system for assisting a cell change operation of a Mobile Station (MS) participating in a group call in a Public Land Mobile Network (PLMN), said system comprising:

a Mobile-services Switching Center (MSC) couplable to and having a MSC service area defined by at least one Base Station Controller (BSC) having a first BSC service area at least partially defined by a first cell; and

a Group Call Register (GCR) coupled to and accessible by said MSC, said GCR comprising a database including information defining at least one Group Call Area (GCA) comprising at least said first cell, said database further including information identifying a second cell within said GCA and within a second BSC service area adjacent to said first BSC service area, said information identifying said second cell useable by said MSC to provide parameters associated with said second cell to said MS participating in said group call, whereby said MS can perform a cell change operation when moving from said first cell to said second cell.

10. The system recited in Claim 9, wherein said parameters include cell reselection parameters associated with said second cell.

11. The system recited in Claim 10, wherein said MSC causes said parameters to be communicated to said MS on a control channel associated with the group call channel in the first cell.

12. The system recited in Claim 9, wherein said MSC communicates said information identifying said second cell to said BSC during a setup process associated with said group call.

13. The system recited in Claim 9, wherein said BSC is coupled to said MSC by a second MSC.

14. The system recited in Claim 9, wherein said group call comprises a Voice Group Call Service (VGCS).

15. The system recited in Claim 9, wherein said group call comprises a Voice Broadcast Service (VBS).

16. The system recited in Claim 9, wherein said MS does not perform any transactions with the PLMN during said cell change.

17. A method for assisting a cell change operation of a Mobile Station (MS) participating in a group call in a Public Land Mobile Network (PLMN), said method comprising the steps of:

receiving a group call request at a Mobile-services Switching Center (MSC), said MSC having a MSC service area defined by at least one Base Station Controller (BSC) having a first BSC service area at least partially defined by a first cell;

accessing a Group Call Register (GCR), said GCR comprising a database including information defining at least one Group Call Area (GCA) comprising at least said first cell, said database further including information identifying a second cell within said GCA and within a second BSC service area adjacent to said first BSC service area;

using said information identifying said second cell to provide parameters associated with said second cell to said MS participating in said group call, whereby said MS can perform a cell change operation when moving from said first cell to said second cell.

18. The method recited in Claim 17, wherein said step of using said information comprises the steps of:

setting up a group call channel in said first cell; and

broadcasting said parameters associated with said second cell on a control channel associated with the group call channel in the first cell.

19. The method recited in Claim 17, wherein said parameters include cell reselection parameters associated with said second cell.

20. The method recited in Claim 17, wherein said step of using said information comprises the step of communicating said information identifying said second cell to said BSC during a setup process associated with said group call.

21. The method recited in Claim 17, wherein said BSC is coupled to said MSC by a second MSC.

22. The method recited in Claim 17, wherein said group call comprises a Voice Group Call Service (VGCS).

23. The method recited in Claim 17, wherein said group call comprises a Voice Broadcast Service (VBS).

24. The method recited in Claim 17, wherein said MS does not perform any transactions with the PLMN during said cell change.

FIG. 1

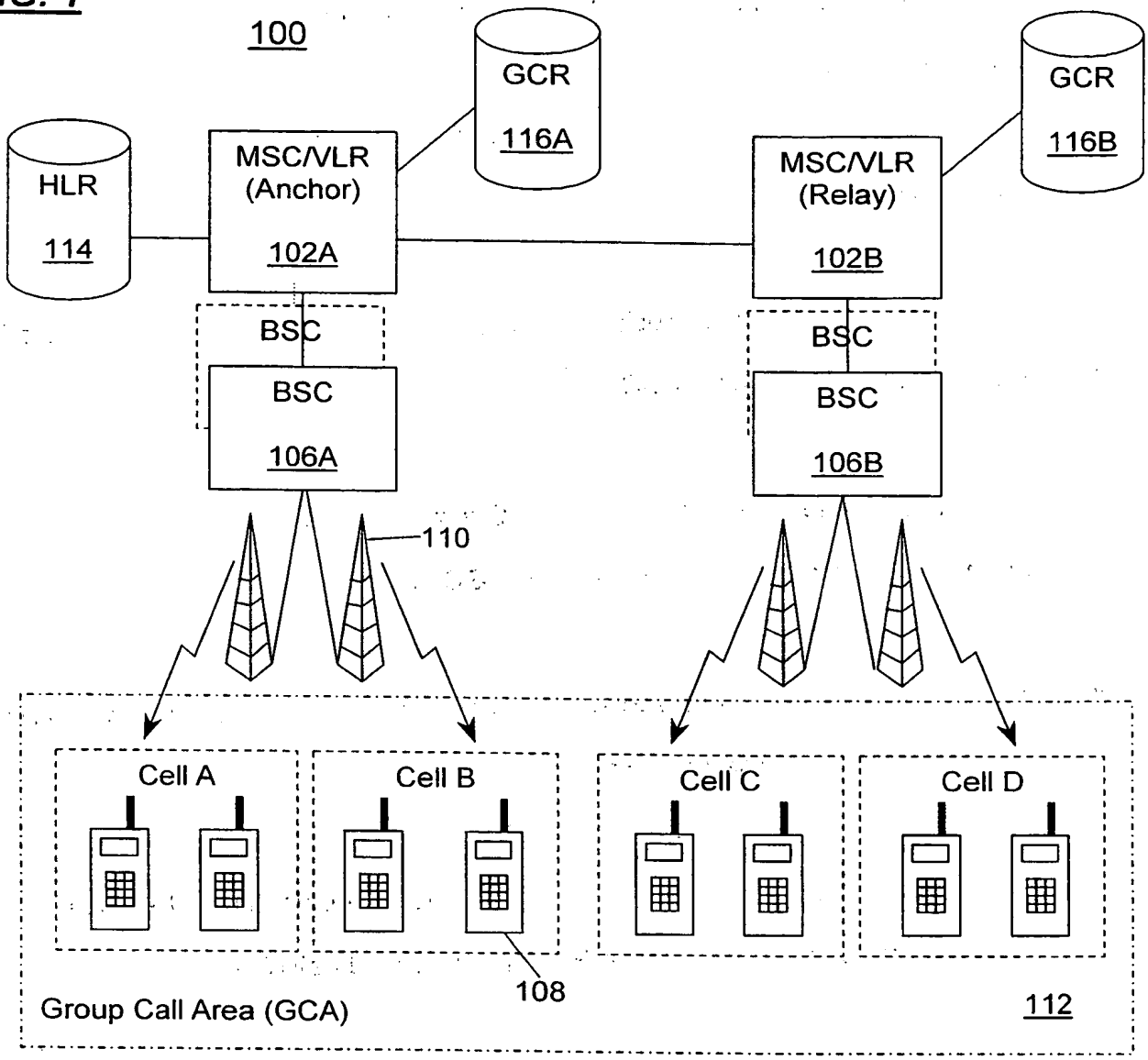

100
GCR
116A
GCR
116B
HLR
114
MSC/VLR
(Anchor)
102A
MSC/VLR
(Relay)
102B
BSC
BSC
106A
BSC
BSC
106B
110
Cell A
Cell B
Cell C
Cell D
108
Group Call Area (GCA)
112

FIG. 2A

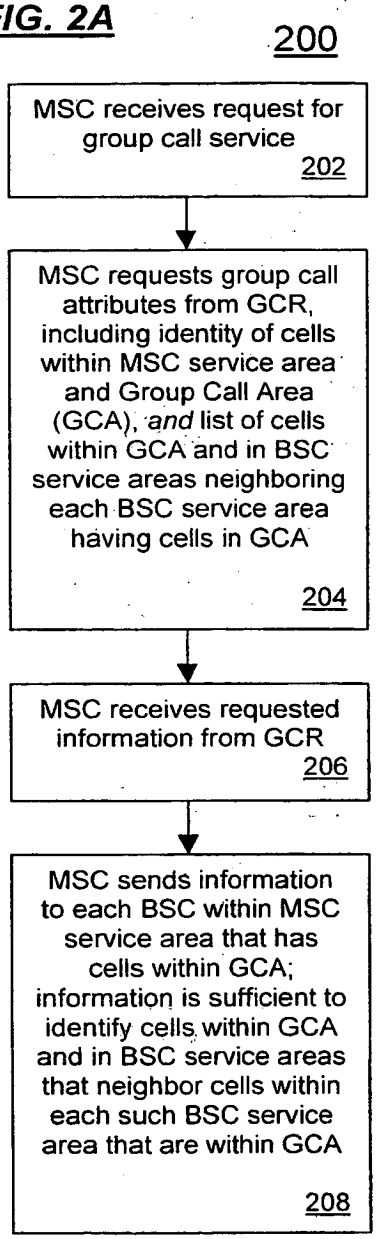

200
MSC receives request for group call service
202
MSC requests group call attributes from GCR, including identity of cells within MSC service area and Group Call Area (GCA), and list of cells within GCA and in BSC service areas neighboring each BSC service area having cells in GCA
204
MSC receives requested information from GCR
206
MSC sends information to each BSC within MSC service area that has cells within GCA; information is sufficient to identify cells within GCA and in BSC service areas that neighbor cells within each such BSC service area that are within GCA
208

FIG. 2B

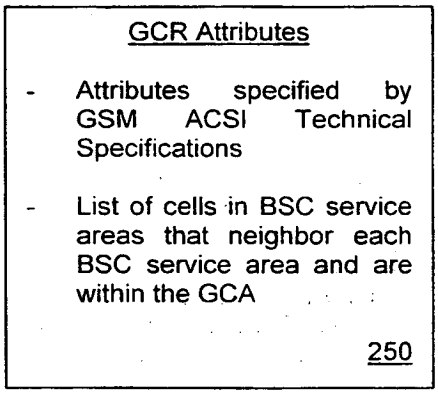

GCR Attributes
- Attributes specified by GSM ACSI Technical Specifications
- List of cells in BSC service areas that neighbor each BSC service area and are within the GCA
250

FIG. 3

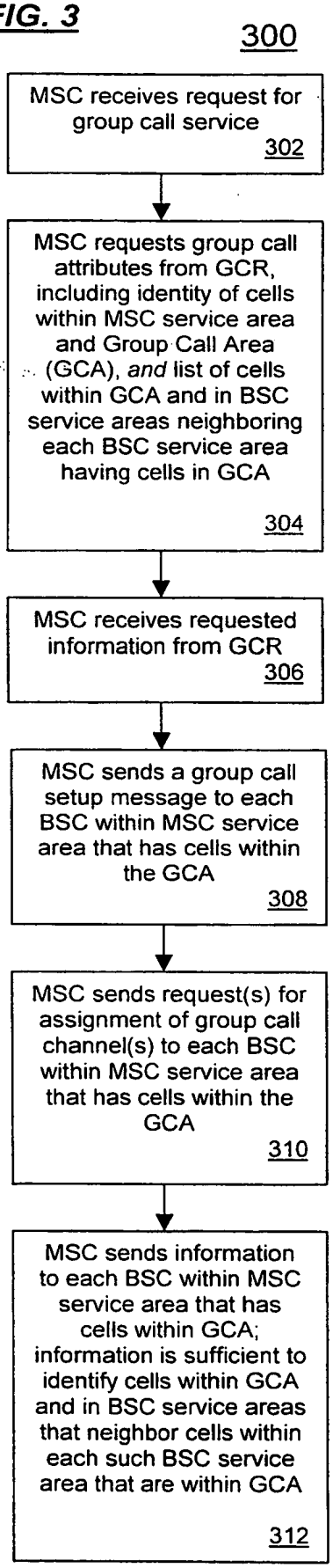

300
MSC receives request for group call service
302
MSC requests group call attributes from GCR, including identity of cells within MSC service area and Group Call Area (GCA), and list of cells within GCA and in BSC service areas neighboring each BSC service area having cells in GCA
304
MSC receives requested information from GCR
306
MSC sends a group call setup message to each BSC within MSC service area that has cells within the GCA
308
MSC sends request(s) for assignment of group call channel(s) to each BSC within MSC service area that has cells within the GCA
310
MSC sends information to each BSC within MSC service area that has cells within GCA; information is sufficient to identify cells within GCA and in BSC service areas that neighbor cells within each such BSC service area that are within GCA
312

FIG. 4

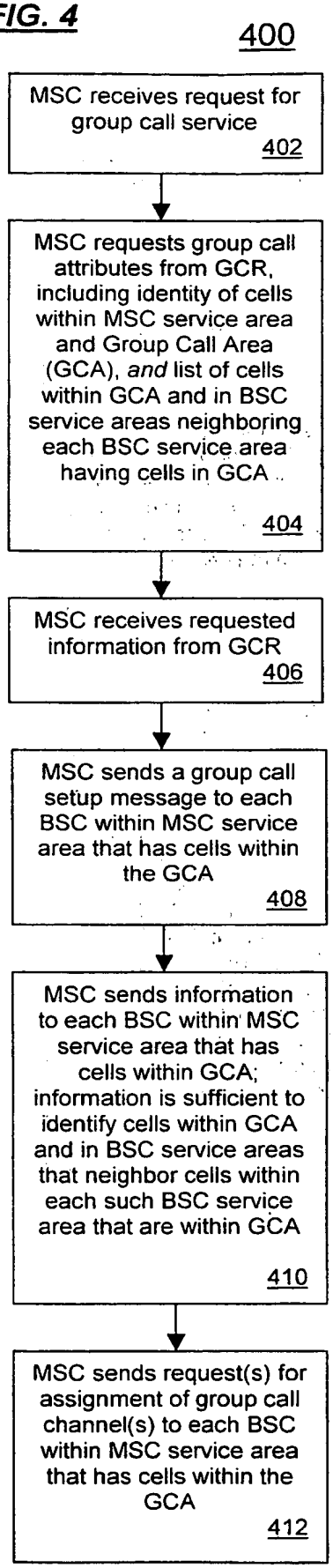

400
MSC receives request for group call service
402
MSC requests group call attributes from GCR, including identity of cells within MSC service area and Group Call Area (GCA), and list of cells within GCA and in BSC service areas neighboring each BSC service area having cells in GCA
404
MSC receives requested information from GCR
406
MSC sends a group call setup message to each BSC within MSC service area that has cells within the GCA
408
MSC sends information to each BSC within MSC service area that has cells within GCA; information is sufficient to identify cells within GCA and in BSC service areas that neighbor cells within each such BSC service area that are within GCA
410
MSC sends request(s) for assignment of group call channel(s) to each BSC within MSC service area that has cells within the GCA
412

FIG. 5

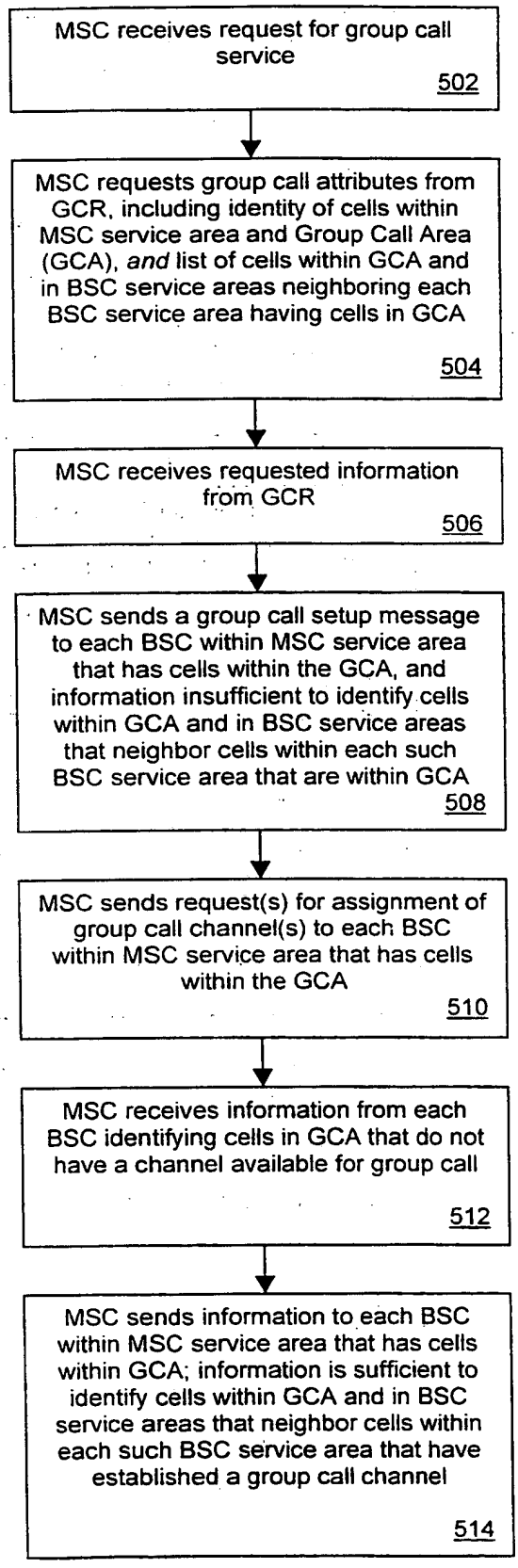

500
MSC receives request for group call service
502
MSC requests group call attributes from GCR, including identity of cells within MSC service area and Group Call Area (GCA), and list of cells within GCA and in BSC service areas neighboring each BSC service area having cells in GCA
504
MSC receives requested information from GCR
506
MSC sends a group call setup message to each BSC within MSC service area that has cells within the GCA, and information insufficient to identify cells within GCA and in BSC service areas that neighbor cells within each such BSC service area that are within GCA
508
MSC sends request(s) for assignment of group call channel(s) to each BSC within MSC service area that has cells within the GCA
510
MSC receives information from each BSC identifying cells in GCA that do not have a channel available for group call
512
MSC sends information to each BSC within MSC service area that has cells within GCA; information is sufficient to identify cells within GCA and in BSC service areas that neighbor cells within each such BSC service area that have established a group call channel
514

FIG. 6

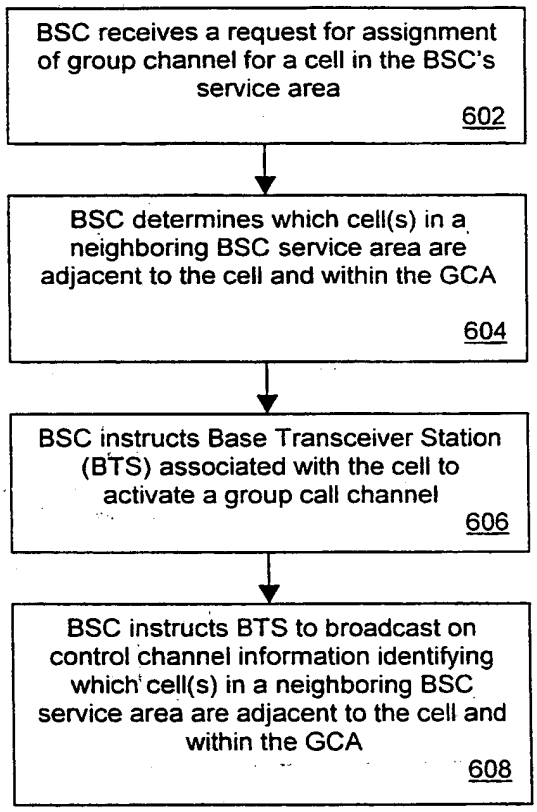

600
BSC receives a request for assignment of group channel for a cell in the BSC's service area
602
BSC determines which cell(s) in a neighboring BSC service area are adjacent to the cell and within the GCA
604
BSC instructs Base Transceiver Station (BTS) associated with the cell to activate a group call channel
606
BSC instructs BTS to broadcast on control channel information identifying which cell(s) in a neighboring BSC service area are adjacent to the cell and within the GCA
608

FIG. 7

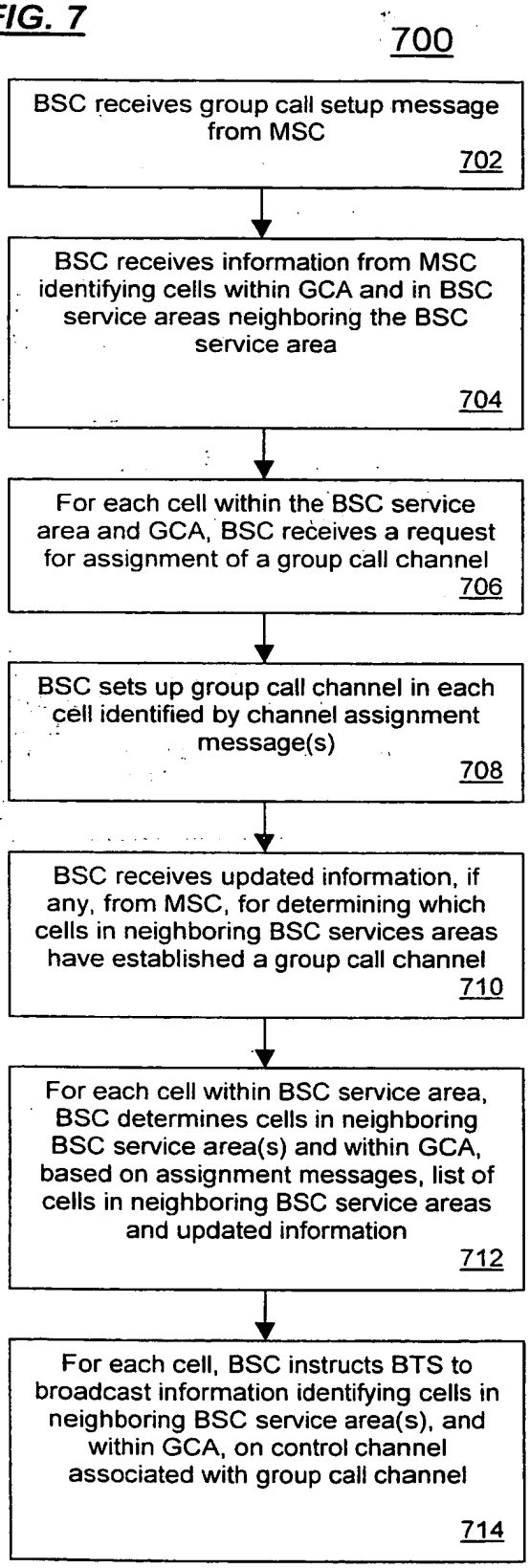
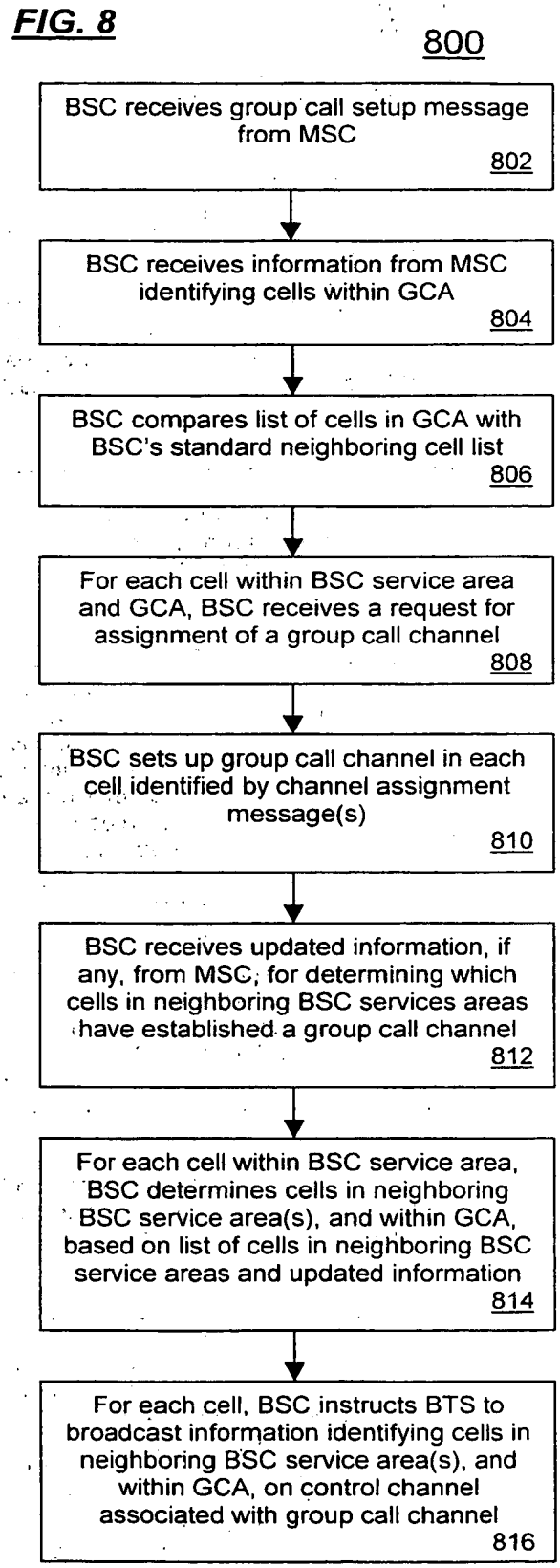

700
BSC receives group call setup message from MSC
702
BSC receives information from MSC identifying cells within GCA and in BSC service areas neighboring the BSC service area
704
For each cell within the BSC service area and GCA, BSC receives a request for assignment of a group call channel
706
BSC sets up group call channel in each cell identified by channel assignment message(s)
708
BSC receives updated information, if any, from MSC, for determining which cells in neighboring BSC services areas have established a group call channel
710
For each cell within BSC service area, BSC determines cells in neighboring BSC service area(s) and within GCA, based on assignment messages, list of cells in neighboring BSC service areas and updated information
712
For each cell, BSC instructs BTS to broadcast information identifying cells in neighboring BSC service area(s), and within GCA, on control channel associated with group call channel
714

FIG. 8


800
BSC receives group call setup message from MSC
802
BSC receives information from MSC identifying cells within GCA
804
BSC compares list of cells in GCA with BSC's standard neighboring cell list
806
For each cell within BSC service area and GCA, BSC receives a request for assignment of a group call channel
808
BSC sets up group call channel in each cell identified by channel assignment message(s)
810
BSC receives updated information, if any, from MSC, for determining which cells in neighboring BSC services areas have established a group call channel
812
For each cell within BSC service area, BSC determines cells in neighboring BSC service area(s), and within GCA, based on list of cells in neighboring BSC service areas and updated information
814
For each cell, BSC instructs BTS to broadcast information identifying cells in neighboring BSC service area(s), and within GCA, on control channel associated with group call channel
816